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Accelerated recovery protocol in total knee replacement patients: reducing pain and opioid consumption with adductor canal block

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ABSTRACT

Aims: This study aims to evaluate the effects of ultrasound-guided adductor canal block (ACB) on postoperative pain control, opioid consumption, and discharge time in total knee arthroplasty (TKA) operations performed in accordance with enhanced recovery after surgery (ERAS) protocols.

Methods: This prospective randomized controlled trial was conducted at Pamukkale University Hospital after obtaining ethical approval. A total of 60 patients who underwent TKA under spinal anesthesia were randomly assigned into two groups. Group I received only local infiltration analgesia (LIA), while group II received both LIA and an ACB. The groups were compared in terms of postoperative Visual Analog Scale (VAS) score at rest and during first ambulation, comparison of tramadol use, dosage, and side effects, time to first ambulation, ambulation distance, quadriceps muscle strength scores, and patient satisfaction and hospital discharge times.

Results: Group II showed consistently lower VAS scores compared with group I at all time points, including rest, walking, and sleep ($p<0.05$). Opioid consumption was significantly higher in group I ($p=0.027$), and readiness for discharge was delayed in group I compared with group II ($p<0.05$).

Conclusion: In patients undergoing TKA, the combination of LIA and ACB appears to be an effective option in multimodal analgesia practices during the postoperative period and may provide potential benefits in accelerating recovery and reducing opioid-related side effects.

Keywords: Adductor canal block, functional recovery, knee arthroplasty, opioid consumption, postoperative pain, regional anesthesia

INTRODUCTION

Prof. Dr. Henrik Kehlet pioneered the development of enhanced recovery after surgery (ERAS) protocols in the 1990s, which aim to accelerate the recovery process after surgery. These protocols include a comprehensive approach, starting from the preoperative preparation period, through the patient's discharge and recovery at home.[1] In 2019, the ERAS Association published a consensus report that includes recommendations for the implementation of these protocols in total knee and hip replacement surgeries, including patient education, development of anesthesia practices, and the use of multimodal analgesia methods.[2]

Effective pain management after total knee arthroplasty (TKA) is critical to patient recovery. A multimodal analgesia approach is recommended for pain control after TKA, and peripheral nerve blocks (PNBs) are essential to this strategy.[3] PNBs may offer several advantages compared to central blocks, especially in patients with comorbidities such as dementia and opioid addiction.[4] Opioid use in multimodal analgesia can lead to complications, such as nausea, vomiting, and decreased intestinal motility, resulting in prolonged hospital stays.[5] Adductor canal block (ACB) is considered a method that provides analgesia like femoral nerve blocks. ACB is especially preferred in lower limb surgeries such as total knee replacement, anterior cruciate ligament reconstruction, and meniscus repair because it provides effective pain control without causing loss of quadriceps muscle strength.[6]

The hypothesis of our study is that ACB will provide effective analgesia, alleviate postoperative pain, reduce opioid requirements, and shorten the hospital stay of patients. Accordingly, this study aimed to evaluate the effects of ultrasound-guided ACB on postoperative pain control, opioid consumption, and discharge time in TKA operations performed in accordance with ERAS protocols.

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METHODS

This prospective randomized controlled trial was conducted at Pamukkale University Hospital between January 8 and October 30, 2020, following ethical approval obtained from the Non-interventional Clinical Researches Ethics Committee of Pamukkale University (Date: 08.01.2020, Decision No: E.1710). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Patients aged 18 to 40 years who underwent elective TKA under spinal anesthesia with Local infiltration analgesia (LIA) and had American Society of Anesthesiologists (ASA) classification I-III were included in this study. Patients with any of the following conditions were excluded: had already undergone TKA surgery, had coagulopathies or drug allergies, were addicted to drugs or alcohol, had infections or anatomical structural problems at the injection site, had severe liver or kidney failure, uncontrolled diabetes, neuropathy, severe heart or lung disease, were pregnant or lactation period, or were morbidly obese.

Patients were informed about the methods to be used, and their written consent were obtained for the study. Patients who refused to participate in the study or whose data were missing during follow-up were excluded from the study.

Patient selection was made using the sealed envelope randomization method and the patients were divided into two groups: group i without ACB and group II with ACB.

All patients received preemptive analgesia with oral acetaminophen 500 mg three times a day for three days preoperatively. Midazolam (0.03mg/kg/IV) was administered to patients for preoperative sedation; granisetron (3 mg/IV) was administered to patients at risk of nausea and vomiting; antibiotic prophylaxis was provided. Upon arrival in the operating theater, vital signs were monitored noninvasively following ASA standards. Intravenous access was established, and supplemental oxygen was provided via nasal cannula. The same anesthetist used 10 mg of 0.5% hyperbaric bupivacaine to perform spinal anesthesia in the lateral decubitus position. Once sensory and motor block were achieved, patients were moved to the supine position, surgery commenced, and they were recorded as group I.

In group II, following spinal anesthesia, patients were positioned supine once sensory and motor block were achieved. Then, under ultrasound guidance (GE LOGIQ-E, USA), the linear probe was used to the medial of the patella and thigh fold, and the depth was adjusted to 4 cm. The adductor canal, bounded by the femoral artery vastus medialis and sartorius muscles, is shown along the short axis and needle with an in-plane technique. For the ACB, a 10 cm Stimuplex (B. Braun R) needle was carefully inserted approximately 2.5 cm into the canal. Initially, the patient was administered 2 ml of a test dose from a 20 ml mixture containing 15 ml of 0.5% bupivacaine, 4 ml saline, and 1 ml epinephrine. Upon successful verification of the needle placement, the remaining anesthetic mixture was given to complete the block.

The Ranawat Orthopaedic Center (ROC) Cocktail (0.5% bupivacaine hydrochloride 20 ml, 50 μg fentanyl, 1 g cefazolin sodium, 0.3 ml 1:1000 epinephrine, and 50 mL %0,9 saline solution) for LIA around the knee of each patient before and after the implant was put in place by the same surgeon.

Following surgery, patients received acetaminophen intravenously at a dose of 10 mg/kg every 6 hours, not exceeding a total daily dose of 4 grams and 75 mg of intramuscular diclofenac sodium every 12 hours. Rescue analgesia, 1 mg/kg of tramadol intravenously, was provided if the Visual Analog Scale (VAS) score was above three with a maximum total daily dose of 400 mg.

The sensory block in the ACB group was evaluated by cold stimulation in the area covering the dermatome where ACB was administered. The severity of pain was measured with the VAS score both before and after surgery. VAS scores were checked hourly for the first four hours, then at 6, 12, and 24 hours, and at the time of the first ambulation. Adverse effects, the timing and distance of the first ambulation, and rescue analgesic requirements were recorded. Quadriceps muscle strength was assessed using a manual muscle test, scored from 0 to 5 before and 24 hours after surgery.

The Post-Anesthesia Discharge Scoring System (PADSS), which rates criteria such as vital signs, ambulation, postoperative nausea/vomiting, pain, and surgical site bleeding, assesses patients within the first 24 hours following ambulation. Scores ranged from 0 to 2. Patients with a PADSS score of 9 and above were eligible for discharge. A ten-point rating scale following the first ambulation was used to measure patient satisfaction (1: dissatisfied; 10: completely satisfied).

The primary outcome measure of the study was determined as VAS scores measured at rest and during the first ambulation within 24 hours postoperatively. Secondary outcome measures were determined as postoperative tramadol use, dosage, and side effects related to opioid use; first ambulation time in terms of functional recovery, ambulation distance, and patient satisfaction with quadriceps muscle strength at the 24th hour postoperatively and time to be ready for discharge.

Statistical Analysis

The sample size was calculated based on the study by Kastelik et al.[7] A substantial effect size (d=0.7) was used for power analysis, and it was estimated that when at least 26 participants were present for each group, 95% confidence and 80% power would be achieved. SPSS version 25.0 was used to analyze the data. Continuous variables were presented as mean±standard deviation, while categorical variables were reported as counts and percentages. Between-group comparisons were conducted using independent T-tests and Mann-Whitney U tests, and within-group changes were analyzed using the Friedman test. Categorical data were evaluated using Pearson's Chi-square test. A p-value of <0.05 was considered statistically significant.

RESULTS

We successfully enrolled 100 patients during the study period. However, 37 patients who met the exclusion criteria, which

included [specific exclusion criteria], were excluded. Initially, our study included 63 patients scheduled for TKA, allocated in two groups. Three randomized patients were excluded from the study because of failed spinal anesthesia. We included 60 patients in the analysis (Figure).

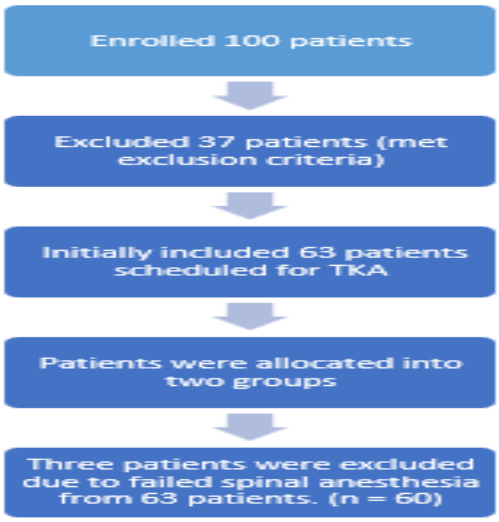
Enrolled 100 patients
Excluded 37 patients (met exclusion criteria)
Initially included 63 patients scheduled for TKA
Patients were allocated into two groups
Three patients were excluded due to failed spinal anesthesia from 63 patients. (n = 60)

Figure. Study flowchart

The study groups were comparable in age, body-mass index (BMI), and preoperative VAS scores. Gender differences were not statistically observed between the groups; the distribution of genders was 20% male and 80% female. Educational status was examined in the groups. While there was one patient in the illiterate group I, three patients in group II were illiterate. Two patients were who were university graduates in group II, and none in group I, and the number of primary school graduates in both groups was equal. Eleven patients (18.3%) were classified as ASA 1, 48 patients (80%) as ASA 2, and 1 patient (1.7%) as ASA 3. The groups' ASA classifications were found to be similar. Three patients (10%) in group II reported having allergies to penicillin-class medications (Table 1).

Table 1. Demographic data

	Group I (mean±SD) (n=30)	Group II (mean±SD) (n=30)	p-value
Age (years)	66.87±6.72	65.80±6.53	0.525*
BMI (kg/m²)	30.51±5.85	31.06±4.16	0.677*
Sex, n (%)			
Female	25 (83.3%)	23 (76.7%)	0.374†
Male	5 (16.7%)	7 (23.3%)	0.374†
Preoperative VAS	7.07±1.11	7.10±1.06	0.906*
ASA physical status, n (%)			
I	7 (23.3%)	4 (13.3%)	0.386† - -
II	23 (76.7%)	25 (83.3%)	
III	0 (0%)	1 (3.3%)	
Drug allergy, n (%)			
Yes	0 (0%)	3 (10%)	0.119† -
No	30 (100%)	27 (90%)	

SD: Standard deviation, p< 0.05 statistically significant difference; *: Independent T-test, †: Chi-square analysis, BMI: Body-mass index, VAS: Visual Analog Scale, ASA: American Society of Anesthesiologists

In the first 4 postoperative hours, group I had significantly higher VAS scores at rest than group II (p<0.05). After the 4th hour, VAS scores were comparable among the study groups at each time interval. Group I first ambulation VAS (5.40±1.16) was significantly higher than group II (3.90±1.09) (p<0.001) (Table 2).

Table 2. Postoperative VAS score at rest and during first ambulation

Time (hour)	Group I (mean±SD)	Group II (mean±SD)	p-value
1st	2.03±0.47	0.7±0.17	0.002*
2nd	4.43±0.77	1.77±0.27	0.000*
3rd	3.63±0.27	2.7±0.33	0.023*
4th	4.27±0.33	3.33±0.31	0.023*
6th	3.1±0.07	3.07±0.07	0.934*
8th	3.6±0.47	3.47±0.31	0.763*
10th	4.2±0.31	3.1±0.17	0.055*
12th	3.17±0.13	2.13±0.13	0.927*
24th	2.8±0.27	2.27±0.27	0.048*
First ambulation	5.40±1.16	3.90±1.09	0.000*

SD: Standard deviation, p<0.05 indicates a statistically significant difference; *: Mann Whitney U analysis of variance, VAS: Visual Analogue Scale

With a mean duration of 18.2 hours, patients in the ACB group maintained sensory blocks in the L3-L4 dermatomal distribution, indicating ACB's sustained analgesic efficacy. In group II, 13 (43.3%) patients required opioid (tramadol 1 mg/IV) rescue therapy. In group I, 18 patients received rescue therapy once, 11 patients received it twice, and 1 patient received tramadol three times. Maintenance-dose opioid (tramadol 0.5 mg/IV infusion, up to 400 mg/day) analgesia was administered to 3 patients in group I and 7 patients in group II. More opioids were used in group I, and fewer side effects were seen in group II (Table 3).

Table 3. Comparison of tramadol use, dosage, and side effects

	Number of doses	Group I (n=30)	Group II (n=30)	p-value
Tramadol use	0	0	17 (56.7)	p=0.027*
	1	18 (60%)	13 (43.3%)	
	2	11 (36.7)	0	
	3	1 (3.3%)	0	
Tramadol dose (1 mg/kg)	1.	27 (90%)	6 (20%)	p<0.05
	2.	12 (40%)	0	
	3.	1 (3.3%)	0	
Tramadol dose (0.5 mg/kg)	1.	3 (10%)	7 (23.3%)	
Side effects				
Hypotension		4 (13.3%)	0	
Nausea and vomiting		23 (76.6%)	12 (40%)	

p<0.05 indicates a statistically significant difference, *: Chi-square analysis

The time to first ambulation and ambulation distance were comparable between the groups (p>0.05). Group I had higher postoperative quadriceps strength at the 24th hour (4.33±0.61) compared to group II (3.97±0.32) (p=0.05) (Table 4).

Table 4. Time to first ambulation, ambulation distance, and quadriceps muscle strength scores

	Group I (mean±SD) (n=30)	Group II (mean±SD) (n=30)	p-value
First ambulation time (hours)	4.95±1.50	5.0±1.82	0.908
Ambulation distance (minutes)	305.0±151.06	393.33±201.60	0.060
Preoperative quadriceps strength	2.83±0.59	3.03±0.49	0.160
Postoperative quadriceps strength	4.33±0.61	3.97±0.32	0.005

SD: Standard deviation, p<0.05 indicates a statistically significant difference, *: Independent T-test

Patient satisfaction at discharge was significantly higher in group II (8.57±0.90) than in group I (7.53±0.63) (p<0.001). Group II time to hospital discharge was significantly shorter compared to group I (23.15±3.28 vs 30.25±3.77, respectively) (p<0.001) (Table 5).

Table 5. Patient satisfaction and hospital discharge times

	Group I (mean±SD) (n=30)	Group II (mean±SD) (n=30)	p-value
Patient satisfaction at discharge	7.53±0.63	8.57±0.90	<0.000*
Time to hospital discharge (hours)	30.25±3.77	23.15±3.28	<0.000*

p<0.05 statistically significant difference, *: Mann-Whitney U analysis of variance, Patient satisfaction (1 not at all satisfied-10 completely satisfied), SD: Standard deviation

DISCUSSION

In this study, we tested the hypothesis that the ACB, performed under ultrasound guidance in TKA procedures conducted in accordance with ERAS protocols, would provide effective analgesia, reduce postoperative pain, decrease opioid requirements, and shorten hospital stay. We found that in patients who received ACB, VAS scores measured at rest, during ambulation, and during sleep within the first 24 hours postoperatively were significantly lower. Additionally, opioid consumption was lower, the incidence of side effects was reduced, patient satisfaction was higher, and the time to discharge readiness was shorter in the ACB group.

In post-TKA patient populations, Agarwala et al.[9] and Deiter et al.[8] reported mean ages of 64.86 and 67 years, respectively, while our study reported a mean age of 66.33 years. In terms of gender distribution, 80% of our patients were female and 20% male, consistent with literature reporting higher joint problem rates in women in both Western (50.3%–83.7%) and Asian (62.9%–69.7%) populations.[10] Regarding ASA classification, Deiter et al.[8] applied ACB mostly in ASA III patients, while Frassanito et al.[11] reported 31 ASA I, 116 ASA II, and 60 ASA III patients. In our sample, 80% of patients were ASA II and only one was ASA III. The lower ASA scores of our patients might be because patients suitable for the ERAS protocol generally have lower ASA scores.

Goytizolo and others[12] found the preoperative numerical rating scale (NRS) scores at rest between 2.7 and 3.4 and during flexion between 5.7 and 6.3. Sawhney and others[13] reported an average preoperative VAS score of 5.4 among 159 patients across the ACB, LIA, and LIA+ACB groups. Henshaw et al.[14] reported that preoperative VAS scores during movement for patients who were planned for knee arthroscopy were between 7.2 and 7.5. Similarly, in our study, the preoperative VAS average was 7.07 in group I and 7.10 in group II, with a similarity between the groups.

Time-dependent evaluations of postoperative VAS scores demonstrated that ACB+LIA provided superior pain management during walking on the first day, akin to LIA at rest. At the same time, ACB alone showed higher pain levels.[13,15] Studies by Gudmundsdottir et al.[18] confirmed that ACB combined with LIA enhances pain control. Similarly, Hussain et al.[17] demonstrated that while both single-shot and continuous ACB were effective for analgesia, continuous ACB was associated with a higher risk of complications.

In our study, group II consistently demonstrated lower VAS scores than group I at all time points, indicating superior pain management, especially by the 24th hour (p<0.05). The AKB+LIA combination was notably more effective than either treatment alone in managing pain during rest, walking, and sleep, consistent with findings by Sawhney et al.[13] Gudmundsdottir et al.[18] noted similar results for rest pain but reduced movement pain with AKB+LIA. Early postoperative pain control was comparable between AKB and iPACK, but their combined use resulted in higher pain scores after 72 hours.[19] Similarly, Mingdeng's[16] meta-analysis underscored enhanced resting analgesia with AKB+LIA during the first 24 to 48 hours post-operation. Our data also revealed higher first-day pain levels in group I, with VAS scores at rest and during ambulation of 2.60 and 5.40, respectively (p<0.05). Furthermore, nausea and vomiting were more prevalent in group I (76.6%) compared to group II (40%), and opioid usage was significantly lower in group II (p<0.05). These findings align with multimodal analgesia strategies aimed at minimizing opioid use and side effects. Research by Muñoz et al.[21] showed that non-opioid regimens did not enhance outcomes in opioid consumption or pain relief. At the same time, Xing et al.[22] reported that AKB+LIA significantly reduced morphine usage and decreased nausea and vomiting rates. Similarly, Hanson et al.[23] found that AKB effectively lowered pain scores and opioid use in meniscus surgery.

In a randomized controlled trial by Zhou et al.,[24] the combination of AKB+LIA significantly reduced use of tramadol 48 hours after the procedure compared to LIA alone. Li et al.[25] also performed postoperative 6 of AKB + LIA and 24. They found that it significantly reduced morphine consumption during the hours. AKB made with bupivacaine and magnesium increases overall patient satisfaction by reducing pain scores and opioid consumption after TKA without increasing the incidence of nausea.[26] Also, a 2022 study by Ahmad et al.[27] showed that AKB provides adequate pain control after TKA and reduces the need for opioids. In our study, the combination of AKB+LIA required the use of tramadol and other analgesic drugs less compared to group I. It resulted in fewer side effects and better pain control in group II. Our findings are consistent with the data in the literature and show that the combination of AKB and LIA offers a practical solution in postoperative pain management.

AKB+LIA facilitated earlier ambulation, according to a meta-analysis by Ma et al.[28] In a similar study, Biswas et al.[29] assessed functional recovery and ambulation distances among three groups and found no significant differences. In their study comparing three different anesthesia methods for TKA, Perlas et al.[30] discovered that the LIA+AKB group walked a longer distance on the first postoperative day than the other groups. Incorporating interspace between the knee capsule and the popliteal artery into continuous AKB has shown that it enhances postoperative pain control and reduces the need for nalbuphine. However, after the first day, no discernible ambulation or motor power changes were seen.[31] Although the AKB+LIA group showed a longer ambulation distance in our study, this difference was not statistically significant ($p>0.05$).

Gudmundsdottir and Franklin[18] found that adding AKB to a single dose of LIA did not provide additional benefits for pain and ambulation. Still, AKB offered advantages over the femoral nerve block (FSB) in preserving motor functions. Based on the neutrophil/lymphocyte ratio (NLR) and platelet/lymphocyte ratio (PLR) following TKA, a recent study by Domagalska et al.[32] demonstrated that the combination of iPACK and AKB significantly improves pain management, functional recovery and reduces stress responses. Kampitak et al.[33] (X) have stated that AKB+LIA does not negatively affect quadriceps strength and facilitates ambulation. Grevstad et al.[34] compared the effects of FSB and AKB on quadriceps muscle strength. They observed a 16% strength loss in the FSB group, which was not seen in the AKB group, attributing this to AKB reducing centrally mediated inhibition and lacking peripheral motor inhibition caused by FSB. LIA provides adequate pain control without affecting the strength of the quadriceps muscle and offers pain scores similar to FSB and shorter stay durations. At the same time, Gudmundsdottir et al.[18] have noted that LIA provides good analgesia post-TKA but increases the risk of falls by affecting quadriceps muscle strength. A study by Zhou et al.[24] has shown that AKB does not harm quadriceps muscle strength, and correct anatomical placement and appropriate block volume do not spread to the femoral nerve. In our study, the quadriceps strength test results for patients in group II increased from a preoperative average of 3.03 to a postoperative average of 3.97, which can be attributed to adequate analgesia provided by AKB+LIA and improved joint function post-TKA—in their study comparing AKB, LIA, and AKB+LIA groups, Zhou et al.[24] observed higher patient satisfaction in the AKB and AKB+LIA groups during the fourth and eighth postoperative hours. However, Kastelik et al.[7] did not find a significant difference in patient satisfaction in their studies involving LIA and AKB infusions. In our study, higher patient satisfaction was observed in the AKB+LIA group.

Goytizolo et al.[12] found no difference in discharge time between the LIA and AKB+LIA groups. However, Perlas et al.[30] showed that the LIA+AKB group had shorter hospital stays and more discharges than other groups. In our study, the hospital stay duration was 23.15 hours for group II and 30.25 hours for group I, indicating that adding AKB to analgesia positively influenced functional recovery.

Limitations

The limited sample size of our study, its execution at a single center, and the restricted diversity of participants potentially limit the generalizability of our findings. The applicability of our results across broader patient populations and various clinical settings will enable us to obtain more detailed and definitive information about long-term outcomes.

CONCLUSION

We found that in patients who received ACB, VAS scores measured at rest, during ambulation, and during sleep within the first 24 hours postoperatively were significantly lower. Additionally, opioid consumption was lower, the incidence of side effects was reduced, patient satisfaction was higher, and the time to discharge readiness was shorter in the ACB group. In patients undergoing TKA, the combination of LIA and ACB appears to be an effective option in multimodal analgesia practices during the postoperative period and may provide potential benefits in accelerating recovery and reducing opioid-related side effects.

ETHICAL DECLARATIONS

Ethics Committee Approval

Ethical approval obtained from the Non-interventional Clinical Researches Ethics Committee of Pamukkale University (Date: 08.01.2020, Decision No: E.1710).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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